

Ash

White ash, *Fraxinus americana*

Black ash, *Fraxinus nigra*

Green ash, *Fraxinus pennsylvanica*



The volume of ash has increased steadily as have average growth rates. Low mortality is reflected in a below average ratio of mortality to volume. The number of saplings has increased in the past 20 years suggesting that, for now, regeneration is adequate.

This situation may change, however, as the emerald ash borer (EAB) spreads throughout Wisconsin. EAB is expected to cause substantial ash mortality. Mortality has increased 68% statewide and more than tripled in southeast Wisconsin since 2009 although the cause has not been determined.

Ash is not a major roundwood species but is used for pulpwood, sawlogs and fuelwood production. Ash biomass has a higher than average density and may serve as a source for biofuel production, especially if mortality from EAB creates the opportunity for salvage harvesting.

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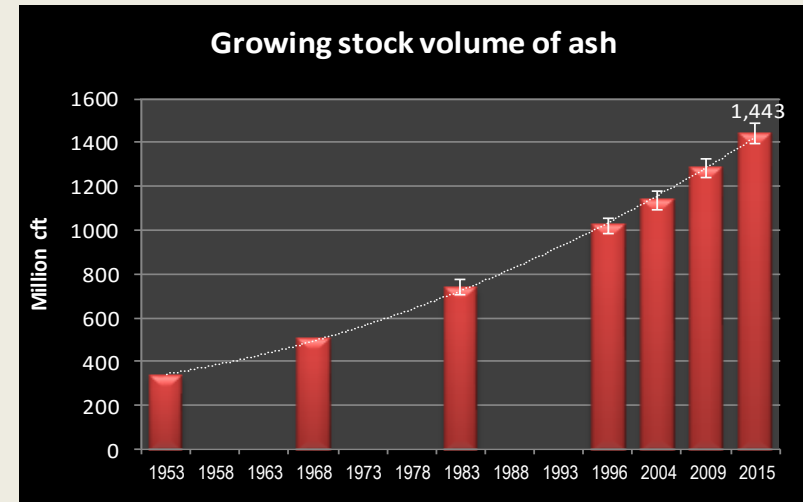
"How has the ash resource changed?"

Growing stock volume and diameter class distribution by year

The [growing stock volume](#) of ash in Wisconsin (chart on right) was about 1.4 billion cubic feet in 2015, accounting for 6.6% of total growing stock volume. Ash volume has increased steadily since 1968 almost doubling since 1983.

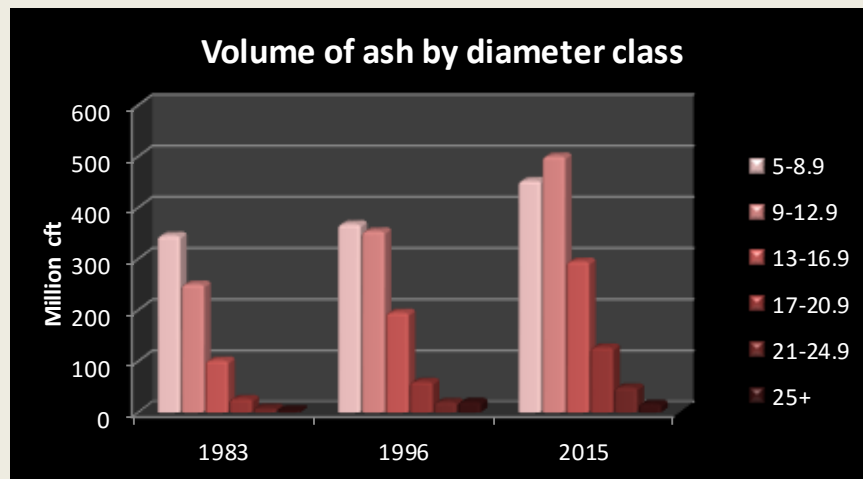
Like many other species, the ash resource is maturing. Volume in large growing stock trees (13+ inches in diameter) has tripled since 1983, whereas volume in smaller trees (5-12.9 inches) has increased by only 59% (chart lower left).

[Sapling](#), [pole](#) and [sawtimber](#) size trees are increasing in number for all three ash species (chart lower right), suggesting that, in the absence of high mortality due to emerald ash borer, ash would maintain its important role in Wisconsin's forests.



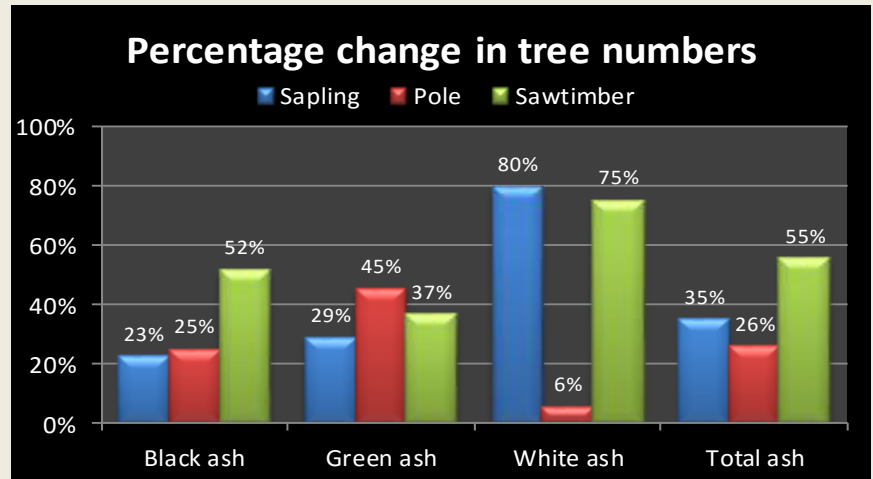
Growing stock volume (million cubic feet) by inventory year. Error bars represent the 68% confidence interval.

Source: USDA Forest Inventory and Analysis data



Growing stock volume (million cubic feet) by diameter class (inches)

Source: USDA Forest Inventory and Analysis data

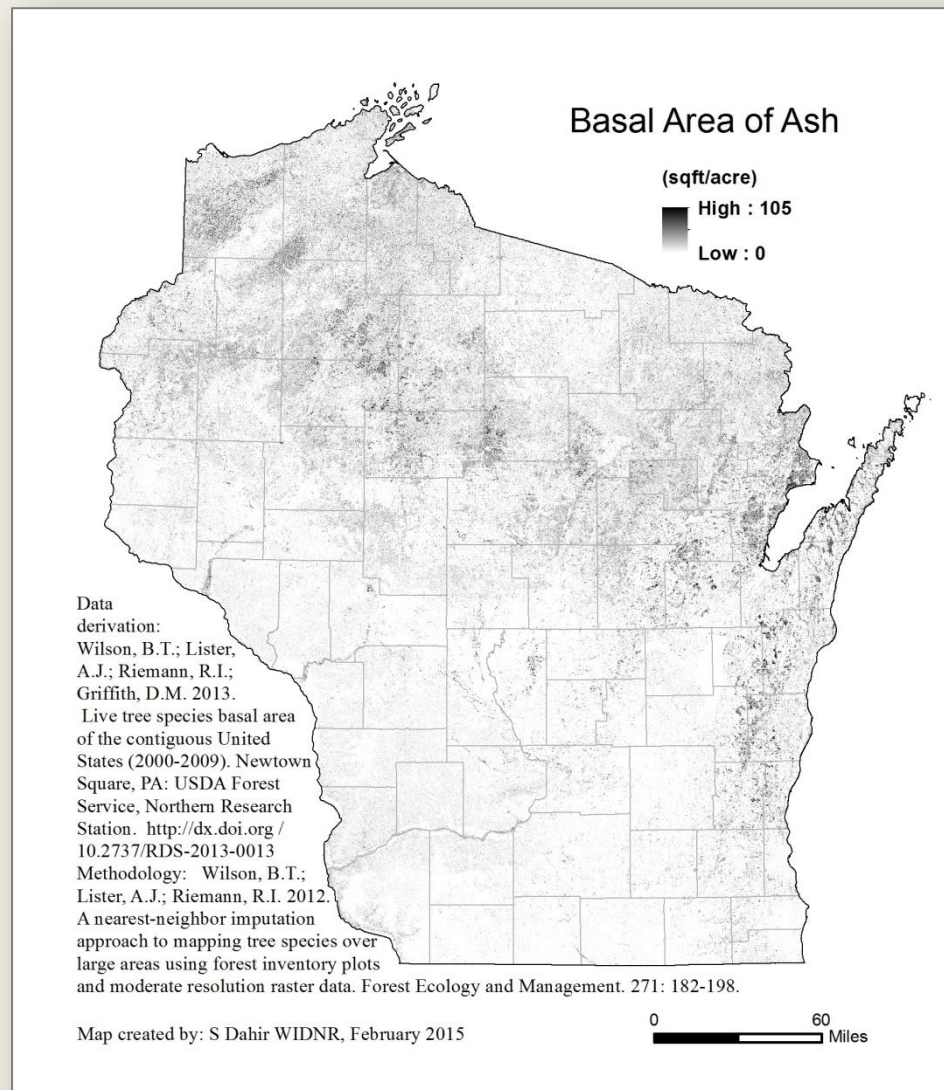


Percentage change in the number of live trees by size class between 1996 and 2015.

Source: USDA Forest Inventory and Analysis data

"Where is ash found in Wisconsin?"

Growing stock volume by region with basal area map



About 60% of ash volume is located in northern Wisconsin and about 30% in the southern part of the state (Table 1).

Black ash occurs mainly in the northwest and on bottomland hardwood [forest types](#). Green ash also prefers wetter sites but is more of a southern species. White ash, on the other hand, grows preferentially on drier soils and is found mostly on maple-basswood forest types and, to a lesser extent, on oak-hickory.

Table 1. Growing stock volume (million cft) by species and region of the state.

Species	Central	North east	North west	South east	South west	Total	% of total
Black Ash	84	126	358	32	26	627	43%
Green Ash	51	63	53	183	26	375	26%
White Ash	65	121	97	72	85	441	31%
Total	200	310	508	287	137	1,443	100%
% of total	14%	22%	35%	20%	10%	100%	

Source: USDA Forest Inventory and Analysis data 2015

For a table on **Volume by County** go to:

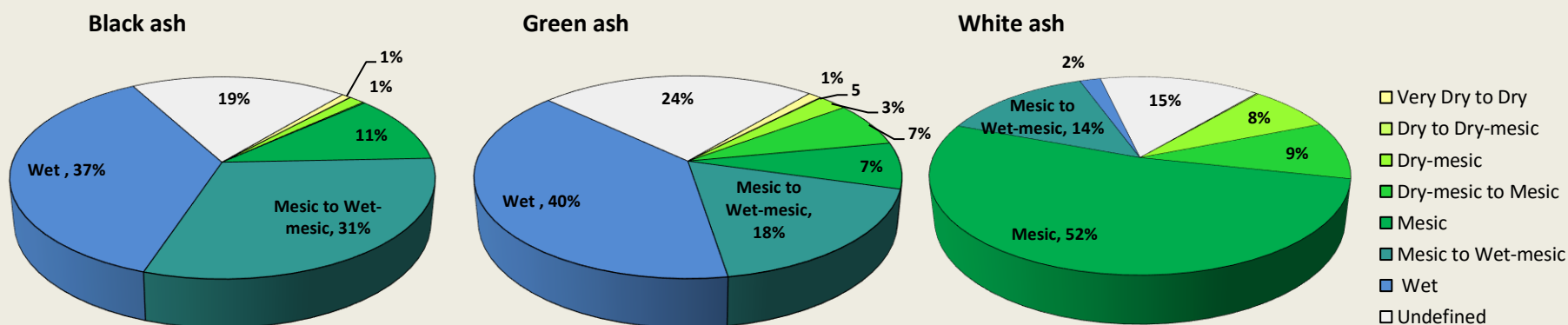
<http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/VolumeCountySpecies.pdf>



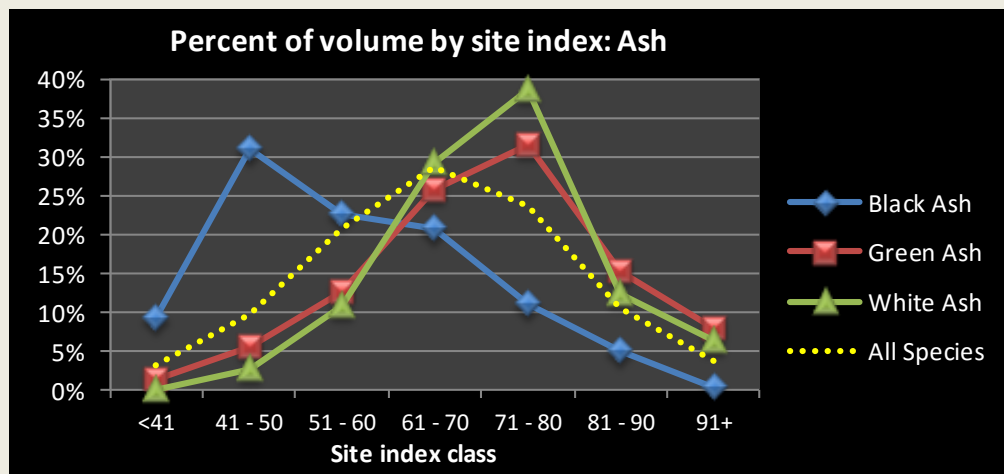
"What kind of sites does ash grow on?"

Habitat type and site index distribution

There is a distinct difference in volume distribution of the 3 ash species with respect to habitat type and site index. In the chart below, 60-70% of growing stock volume of both green and black ash occurs on wetter habitat types. The vast majority of white ash volume occurs on mesic sites.



Percent distribution of growing stock volume by habitat type group for black, green and white ash (USDA Forest Inventory & Analysis data).



Percent distribution of growing stock volume by site index class (USDA Forest Inventory & Analysis data).

With respect to site index, there is a major difference between black ash and the other two species. Black ash occurs mainly on wetter soils in northern Wisconsin. Almost 80% of black ash is found in northern Wisconsin.

Green ash also occurs on wetter habitat types but mainly in southeast Wisconsin. Almost half of green ash volume occurs in southeast Wisconsin and 62% of this is on wet habitat types. Site indices on wet types are about 18% higher in southern Wisconsin compared to wet types in the north.



"How fast is ash growing?"

Average annual net growth by region and year

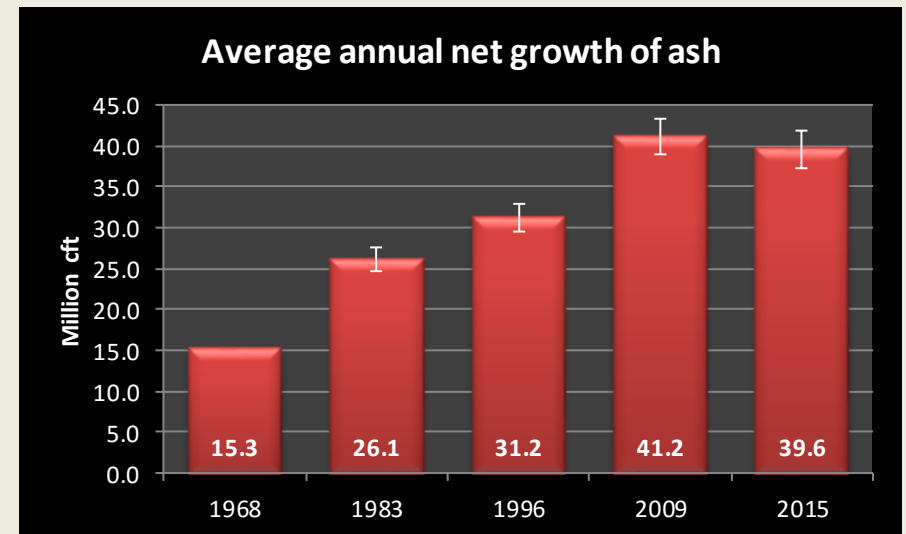
Average annual net growth of ash (chart on right) was about 39.6 million cubic feet per year from 2010 to 2015, corresponding to 7% of total tree growth in Wisconsin in that period. This represents an increase of about 52% since 1983, mainly due to aging trees.

The highest volume growth for ash is in the northwest due to the prevalence of black ash in this region (Table 2). As a percentage of volume, however, the highest growth rate is in the southwest.

Table 2. Average annual net growth (million cft/year) and ratio of growth to volume by region of the state.

Region	Net growth	Percent of total	Ratio of growth to volume
Northeast	9.6	24.3%	3.1%
Northwest	10.6	26.8%	2.1%
Central	6.0	15.2%	3.0%
Southwest	5.1	12.8%	3.7%
Southeast	8.3	20.8%	2.9%
Statewide	39.6	100.0%	2.7%

Source: USDA Forest Inventory & Analysis data: 2015



Average annual net growth (million cubic feet).
Source: USDA Forest Inventory & Analysis data

The average ratio of growth to volume for ash is 2.7%, about the same as the statewide average of 2.7% for all species

For a table of **Average annual growth, mortality and removals by region** go to:
<http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/GrowthMortalityRemovals.pdf>

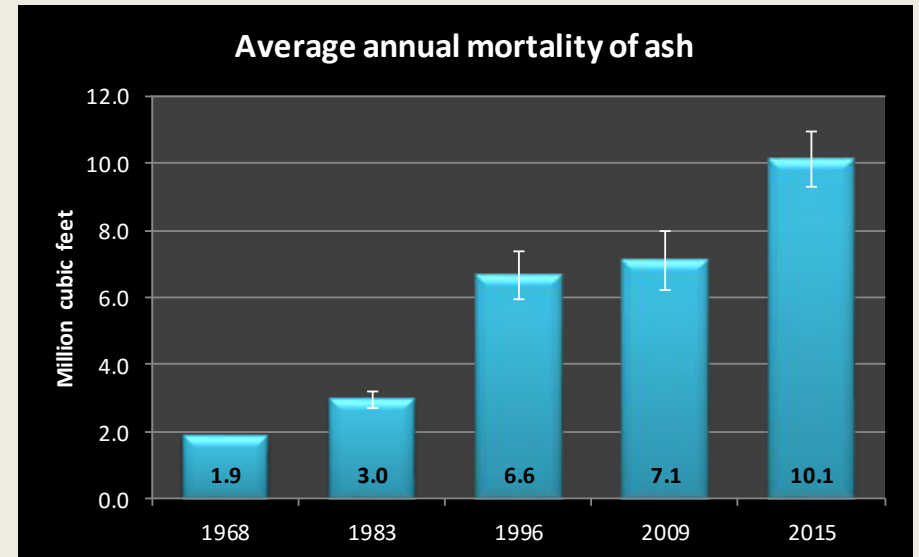


“How healthy is ash in the state?”

Average annual mortality by year and mortality to volume ratio

Average annual mortality of ash, about 10.1 million cubic feet from 2010 to 2015, has more than tripled since 1983 (chart on right), while volume has almost doubled in that time. Mortality increased 45% in the last year in southeast and central Wisconsin.

The ratio of mortality to volume is about 0.7% for all ash species and is highest for green ash (Table 3). The average for all species in Wisconsin is 1.1% indicating that ash has a lower ratio of mortality to growth than average. Ash accounts for 6.6% of total volume and 6.8% of total growth in the state, but only 4.3% of mortality.



Average annual mortality (million cubic feet) by inventory year.
Source: USDA Forest Inventory & Analysis data

Table 3. Mortality and volume of growing stock and the ratio of mortality to volume by species of ash.

Species	Average annual mortality (cft)	Volume (cft)	Mortality/ volume
Black Ash	4,475,602	626,852,599	0.7%
Green Ash	3,443,463	375,151,988	0.9%
White Ash	2,213,760	440,696,655	0.5%
Total Ash	10,132,825	1,442,701,243	0.7%

Source: USDA Forest Inventory & Analysis data

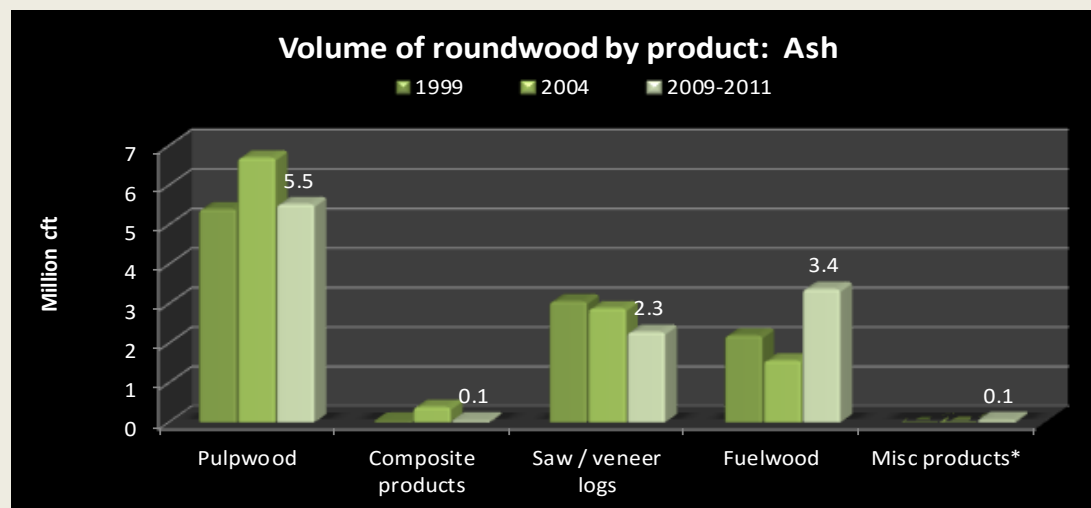
For a table of **Average annual growth, mortality and removals by region** go to:
<http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/GrowthMortalityRemovals.pdf>



“How much ash do we harvest?” Roundwood production by product and year

In 2009, Wisconsin produced about 11.3 million cft of ash roundwood or 2.9% of statewide production. Almost half of this is for pulpwood (chart on right), 20% for sawlogs and 30% for fuelwood.

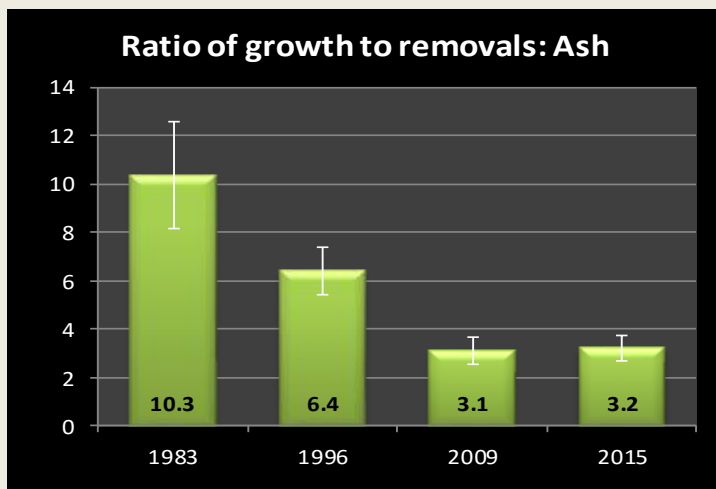
From 2004 to 2009, ash roundwood production had increased by about 3%.



Volume of roundwood. Most recent figures for pulpwood and composite products are from 2011 while other product volumes are from 2009. * Miscellaneous products include poles, posts and pilings.
Source: Ronald Piva, USDA Forest Service, Northern Research Station, St. Paul MN

Removals of ash totaled 12.3 million cubic feet per year from 2010 to 2015 or 3.8% of total growing stock removals.

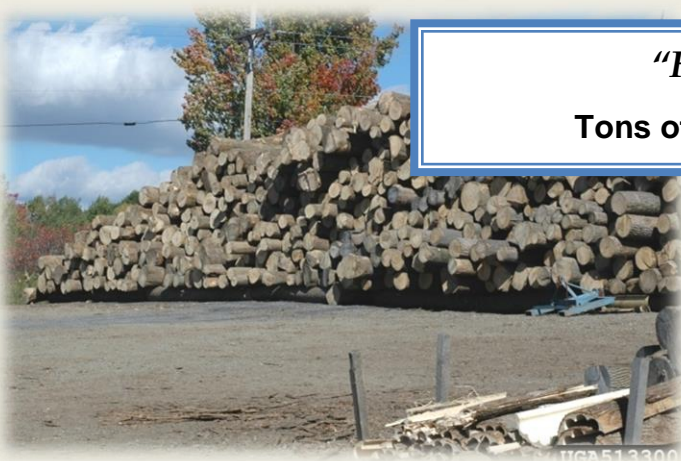
The ratio of annual net growth to average annual removals of ash was 3.2 from 2010 to 2015 about 50% lower than in 1996 (chart on left). The ratio of net growth to removals for ash is higher than the statewide ratio of 1.7 for all species. Statewide we harvest a little over half of all growth but, for ash, we only harvest about 1/3 of total growth.



Source: USDA Forest Inventory & Analysis data.

For a table of **Average annual growth, mortality and removals by region** go to:

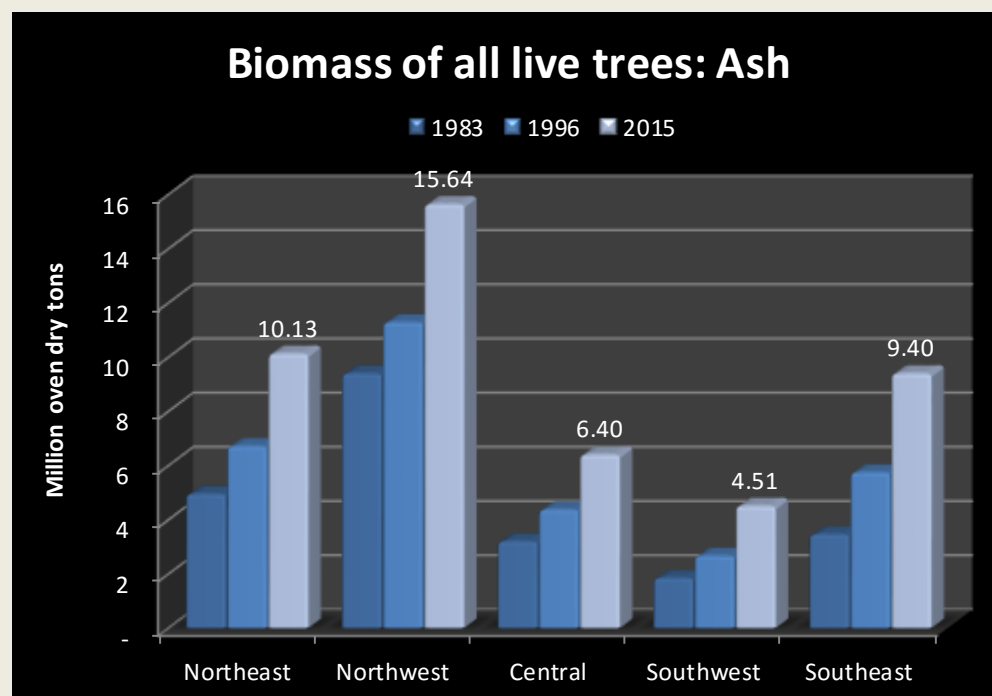
<http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/GrowthMortalityRemovals.pdf>



"How much ash biomass do we have?"

Tons of aboveground biomass by region of the state

There were 46.1 million tons of biomass in live ash trees in 2015, up from about 22.8 million tons in 1983, more than doubling in the last thirty years. This is equivalent to approximately 23 million tons of carbon and represents 7% of all live biomass statewide. As with volume, most of the ash is located in northwest Wisconsin (chart below).



Biomass in live trees by year and region of the state.
Source: USDA Forest Inventory & Analysis data:

Ash is one of the denser hardwoods, with a specific gravity of 0.55 and an oven-dry weight of 34.3 lbs. per cubic foot. The average for all trees is a specific gravity of 0.51 and 31.4 ODP/cft. Approximately 66% of ash above ground biomass is located in the main stem, 16% in bark with 18% in the tops and limbs.

Due to the high density and availability of its wood, ash may become a prominent species for biomass and biofuel production, especially if increased volumes become available due to EAB induced mortality.

For a table of **Biomass by County** go to:

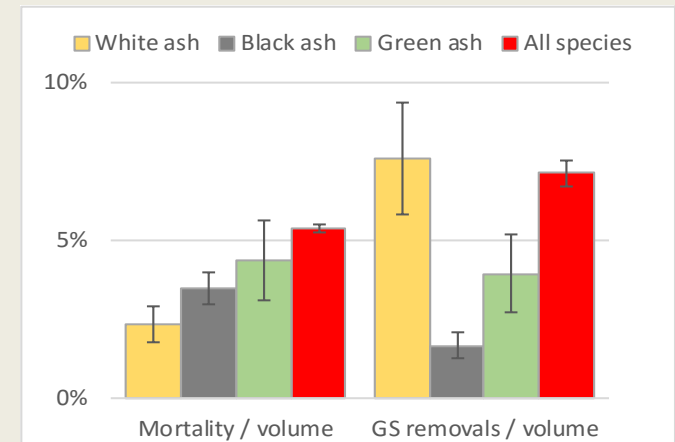
<http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/BiomassByCounty.pdf>

"Can we predict the future of ash?"

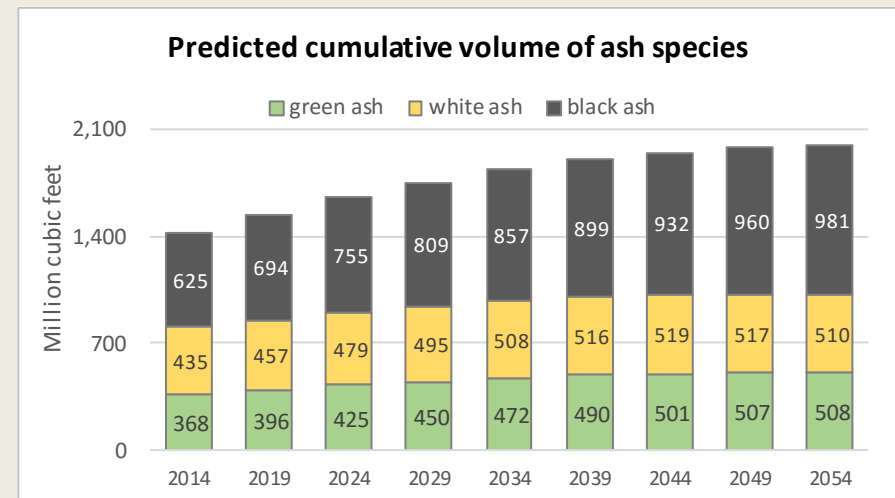
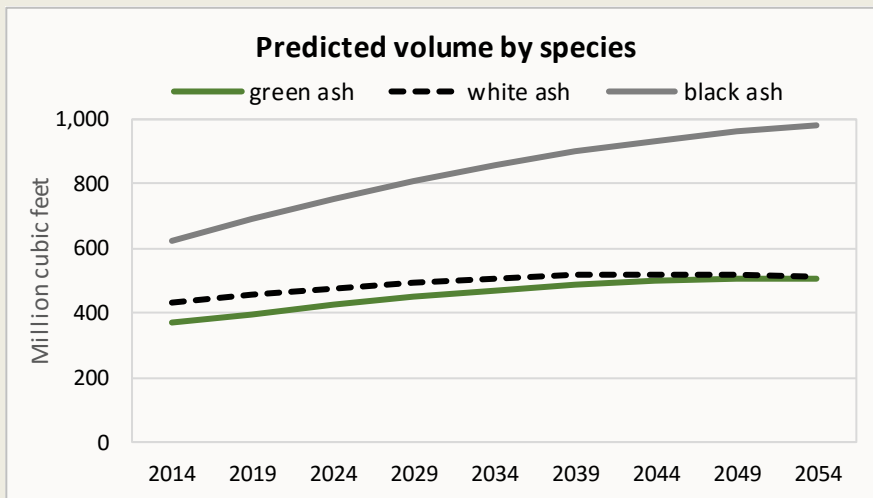
Modelled future volumes of white, green and black ash

The ratio of mortality to volume of growing stock is significantly lower for white and black ash compared to all species in the state and the ratio of removals to volume of growing stock is significantly lower for black and green ash (chart on right).

FVS (Forest Vegetation Simulator¹) was used to predict future volumes of ash through 2054 based on these constant rates of mortality and removals. The volume of all ash is predicted to increase 40% over the next 40 years (chart on lower right). However, the volume of white ash, which has a much higher rate of removals, increases only 17% and starts decreasing in 2049 (chart on lower left). The volume of black ash, which has a significantly lower rate of mortality and removals, increases 57% and green ash volume increases 38%. EAB mortality may of course change this prediction.



Ratio of mortality to volume and removals to volume of growing stock. Error bars show the 68% confidence interval. Source: USDA Forest Inventory & Analysis 2014



Predicted growing stock volumes of white, green and black ash based on 2009-2014 rates of mortality and removals.

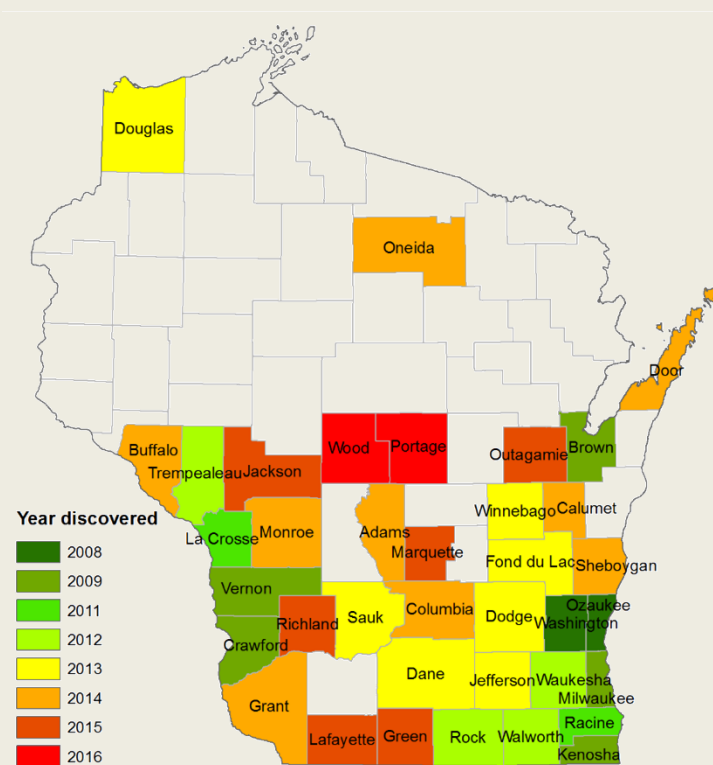
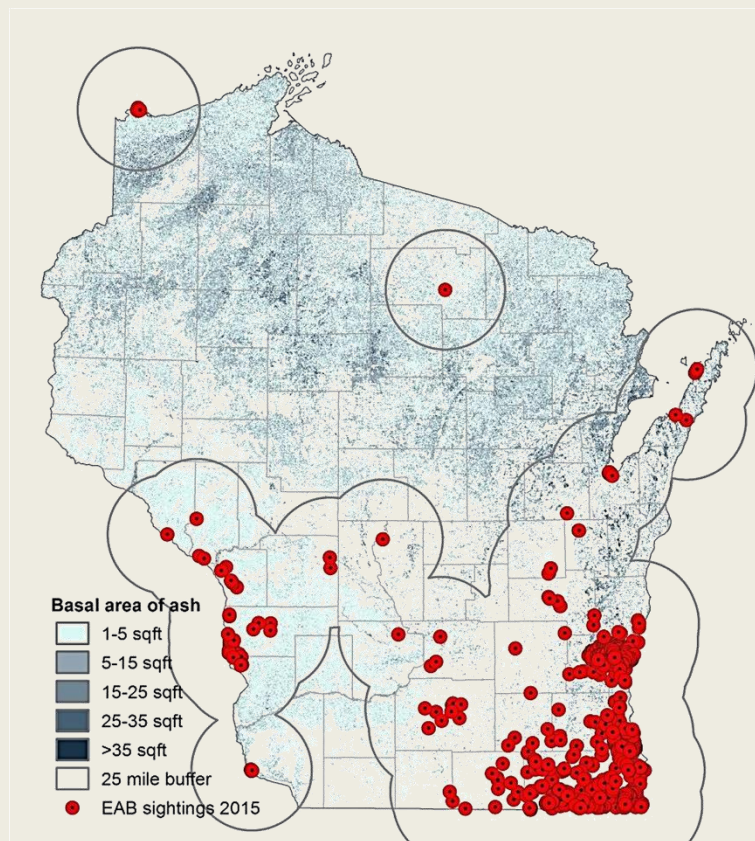


Emerald Ash Borer

Presence in the state and potential impact

Emerald Ash Borer (EAB, *Agrilus planipennis*) is a wood-boring beetle that kills ash trees (*Fraxinus* spp) by eating the living cambium tissue that transports sap and nutrients. Native to Asia, it was probably introduced via wooden shipping crates.

EAB was first detected in Wisconsin in 2008 and, as of the spring of 2016, had been found in 37 counties (map on right). The map on the left below shows 25 mile circles around documented infestations of EAB (as of spring 2015) superimposed on a map of ash basal area. The vast majority of EAB findings have been within and near urban areas with 81% reported within 1 mile of an urban area and 99% within 5 miles.



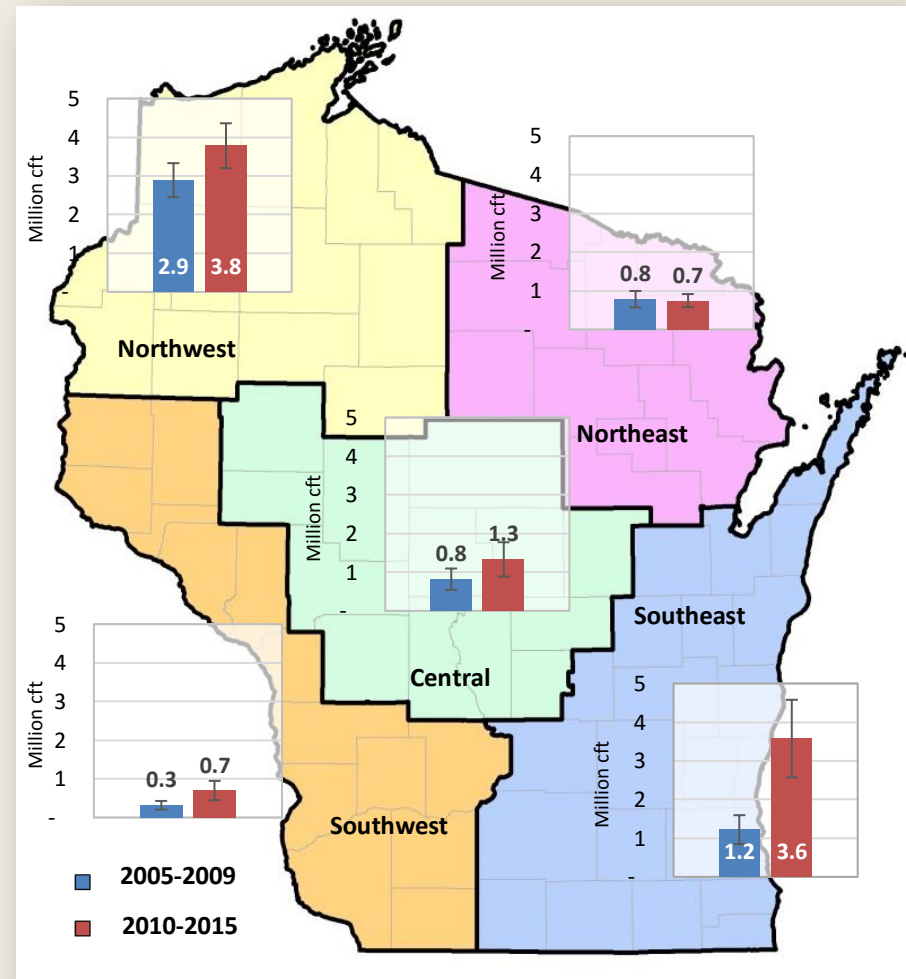


Recent changes in ash mortality by region of the state

Average annual mortality of ash has increased 68% statewide between the period immediately before EAB was found in the state, 2005-2009, and the period following the discovery of EAB, 2010-2015.

This trend has varied by region of the state (figure on the right). For instance, in the Southeast Region where 94% of infested trees and traps have been reported, average annual mortality has almost tripled since 2005-2009. This area of the state hosts 20% of ash volume but 34% of ash mortality. Every region in the state experienced an increase in ash mortality along with volume increases. Northwest and southeast Wisconsin, however, saw significant increases in the ratio of mortality to volume between inventories.

Whether this increased mortality is due to EAB or not, cannot be determined from the Forest Inventory and Analysis (FIA) database. The cause of tree mortality is almost always classified as “unknown” by forest inventory crews. FIA has just begun to inventory plots within urban areas.

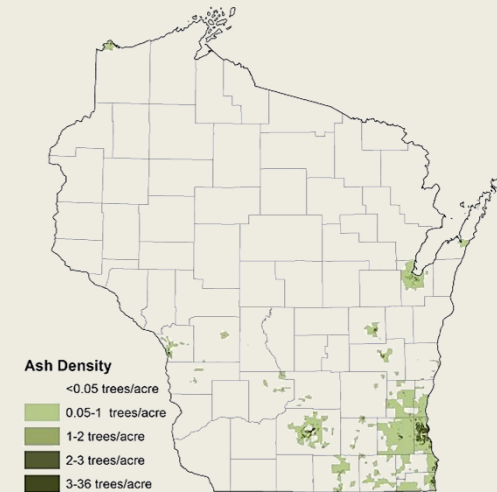


Change in average annual mortality by region of the state for the period before EAB was found in Wisconsin (2005-2009) and the subsequent period (2010-2015).

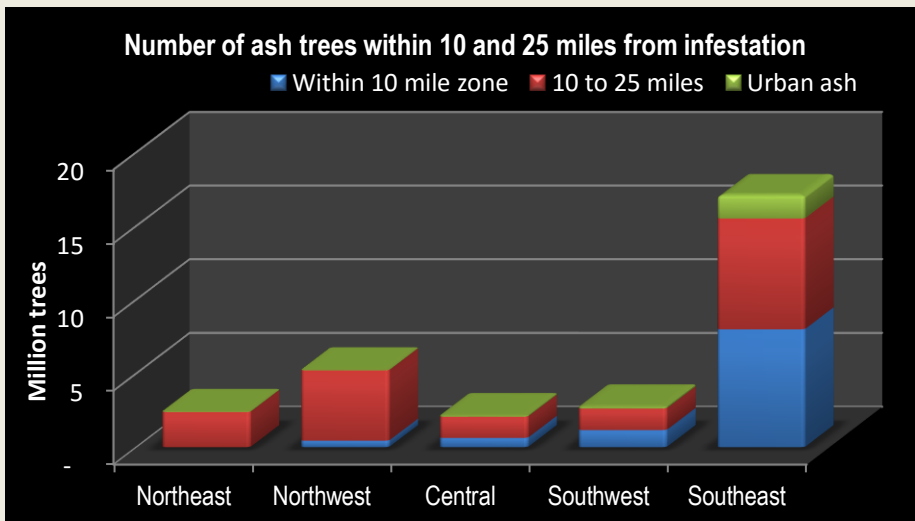
Potential Impact of EAB on Ash Resource

There are 27.8 million growing stock ash trees (16% of all ash) within 25 miles of documented EAB finds and 10.2 million trees (6% of all ash) within 10 miles. However, in the southeast part of the state, over half of all ash is located within 25 miles and over ¼ is within 10 miles of known infestations (chart lower left). About 16% of sawtimber volume in the state is within 25 miles of a documented infestation of emerald ash borer (chart lower right).

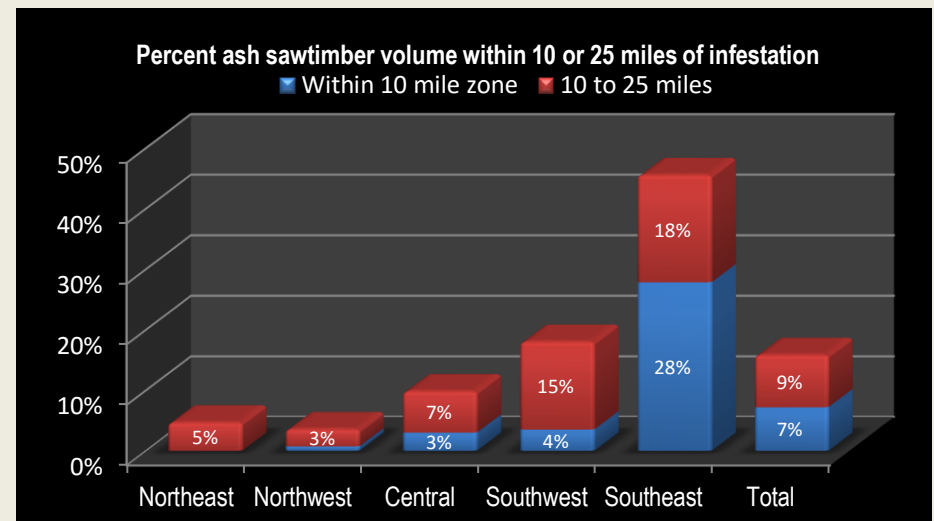
This does not include urban ash however. Studies of ash density in urban areas in the Midwest* have estimated an average of 421.6 trees per 1,000 population. There are 4.4 million people (2010 Census) within 25 miles of documented EAB infestations. This gives an estimated total of 1.5-1.9 million trees in urban areas located within 10-25 miles of infestations in Wisconsin (map on right).



A map of urban ash density within 10 miles of EAB infestations (based on 2010 census).



The number of growing stock (≥ 5 inches dbh) trees within 10 and 25 miles of documented emerald ash borer infestations. Source: USDA Forest Inventory & Analysis 2014



The percentage of sawtimber volume within 10 and 25 miles of known EAB infestations. Source: USDA Forest Inventory & Analysis 2014

*Sydnor, T. Davis, M. Bumgardner, and S. Subburayalu. 2011. Community Ash Densities and Economic Impact Potential of Emerald Ash Borer (*Agrilus planipennis*) in Four Midwestern States Arboriculture & Urban